



What is the most important natural resource issue that the three countries bordering the GOM should address together ?

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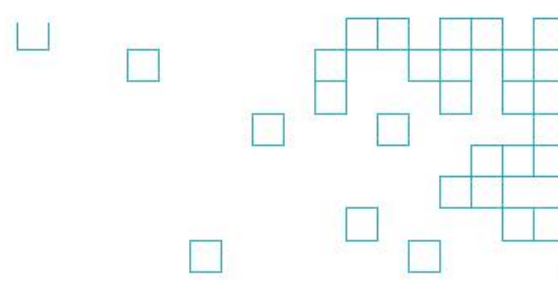
# **Outline: You can only manage what you can measure !**

What do we know about the Gulf of Mexico ?

What do we need to know about the Gulf of Mexico ?

What are the impediments ?

How can the three countries work together to fill the  
gaps?

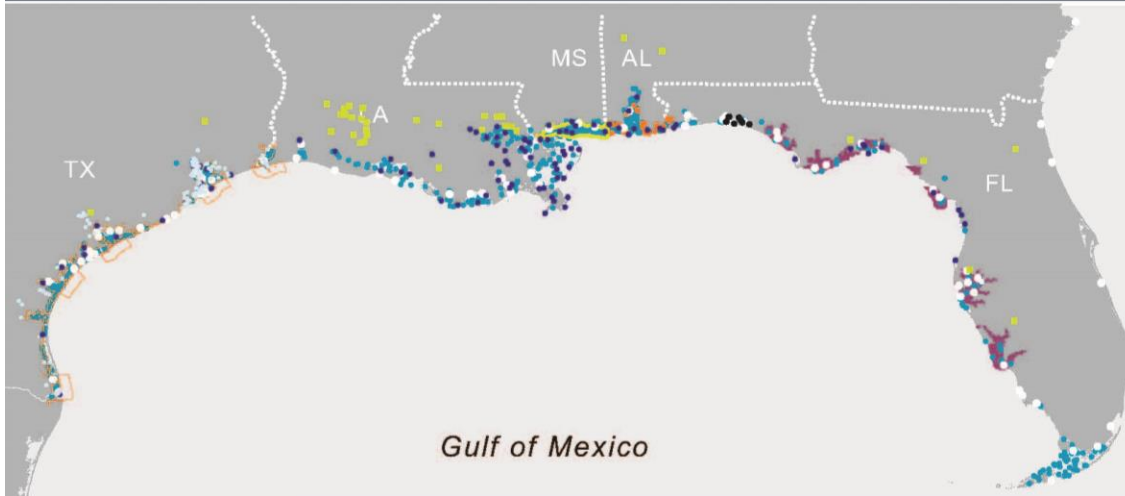


Ocean Conservancy

# CHARTING THE GULF

Analyzing the Gaps in Long-term  
Monitoring of the Gulf of Mexico



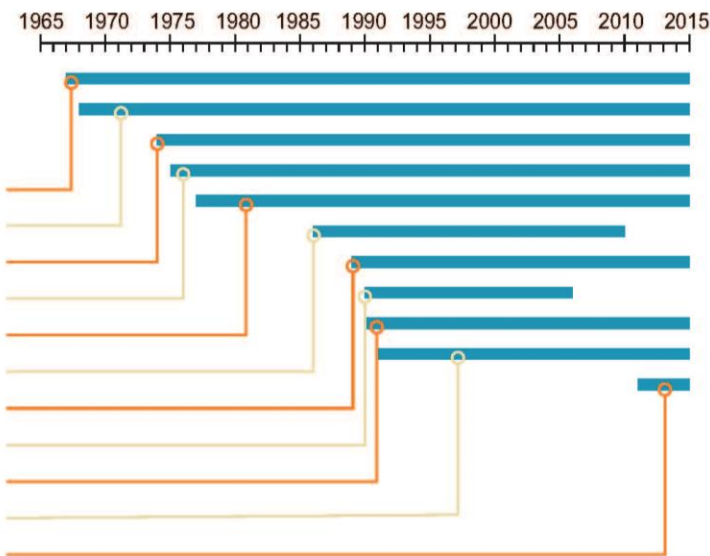


Not shown:  
 (442) LDFW FIM  
 inshore/nearshore seine  
 (119) NOAA NST Bioeffects

\*EPA National Coastal  
 Assessment markers are not  
 necessarily indicative of  
 repeated sampling locations.

## Existing Studies

### NEARSHORE SEDIMENTS & ASSOC. RESOURCES LONG-TERM MONITORING



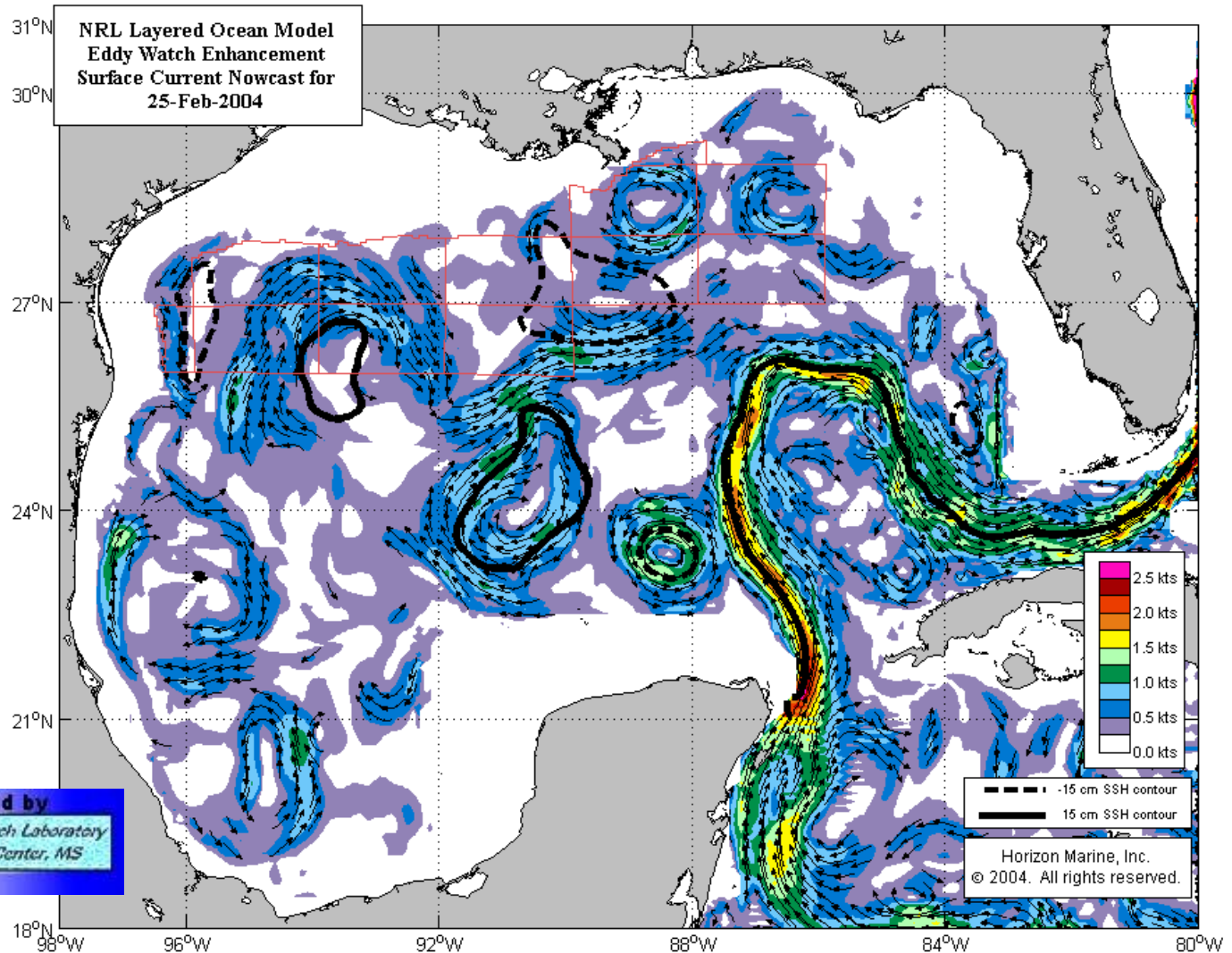
### KEY LESSONS

- *No assessment of physiologic, developmental, or genetic response to oil.*
- *Region-wide surveys not sustained.*
- *Reliance on short-term intensive studies.*

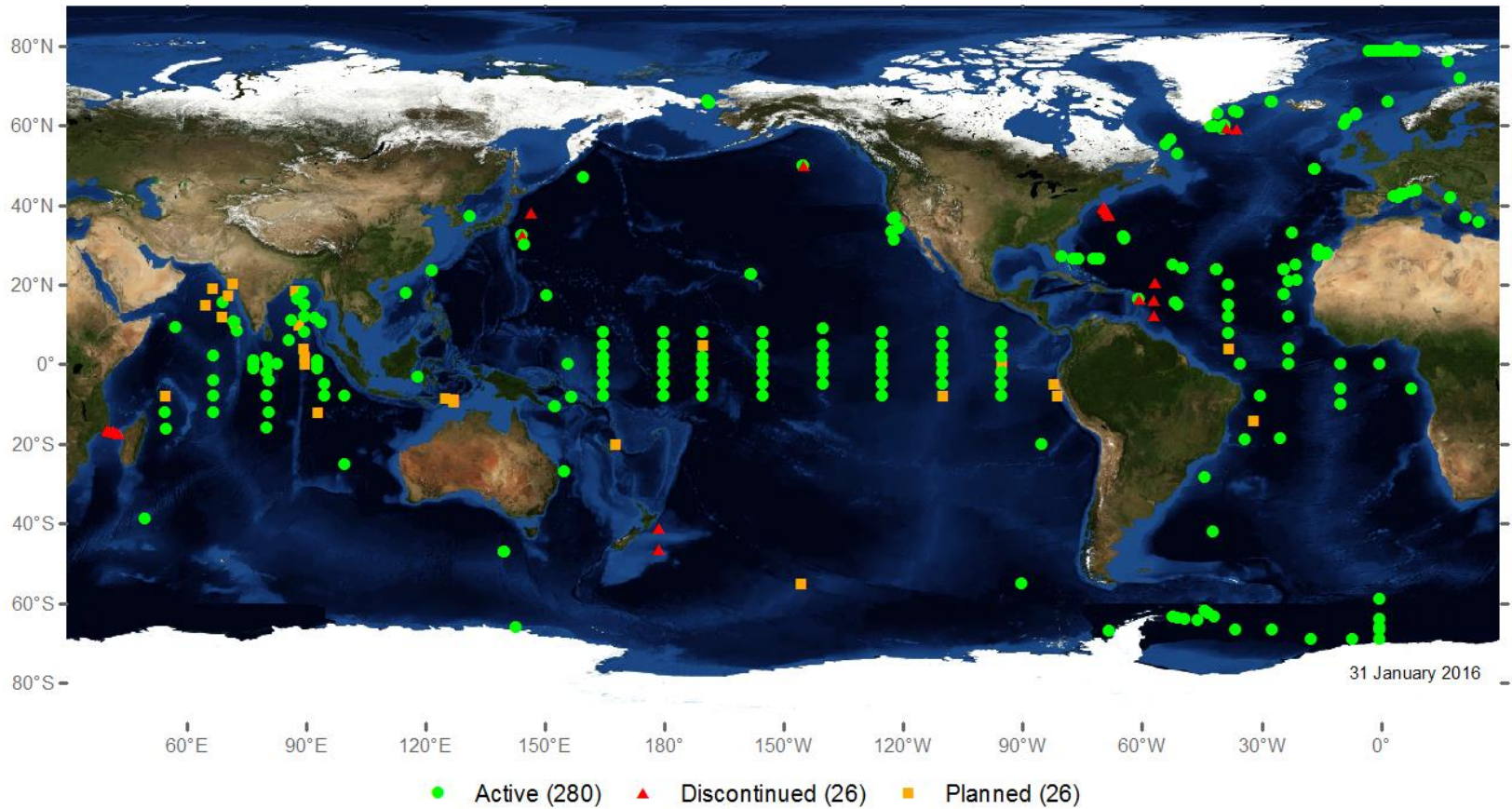


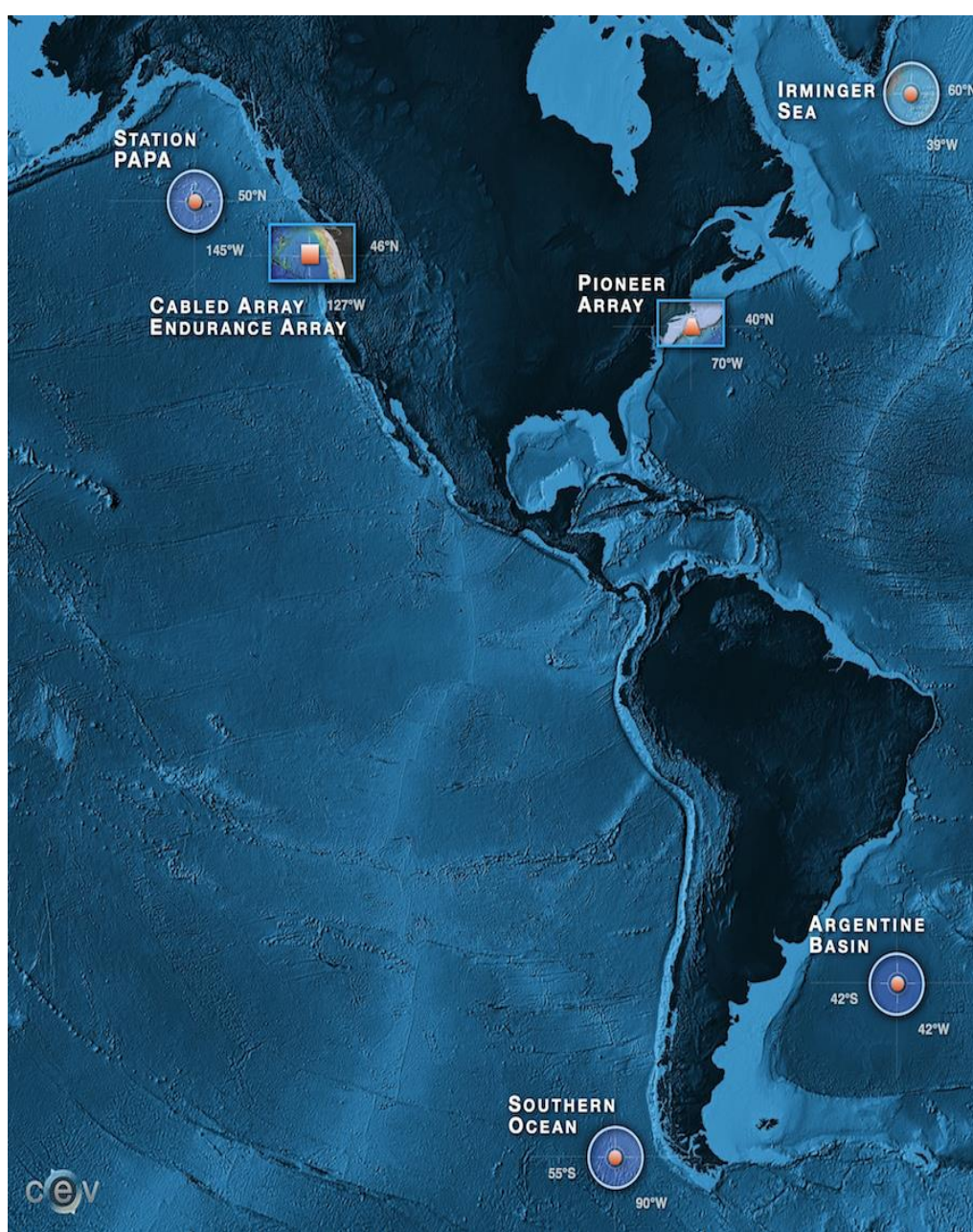
Mullet on sandy bottom

# Feeney and Anderson, Horizon Marine, Inc



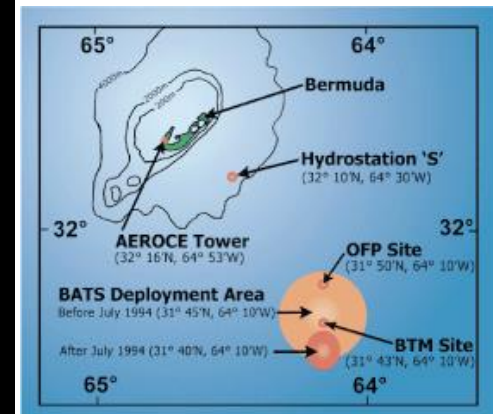
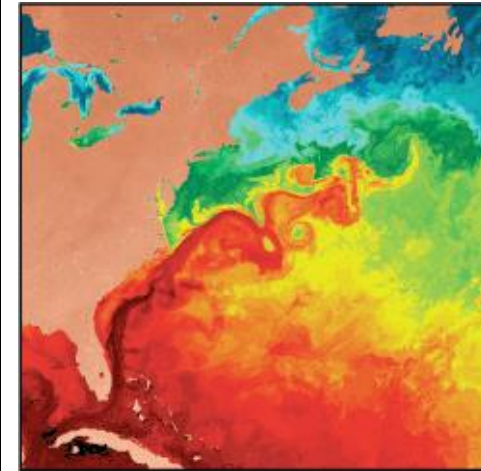
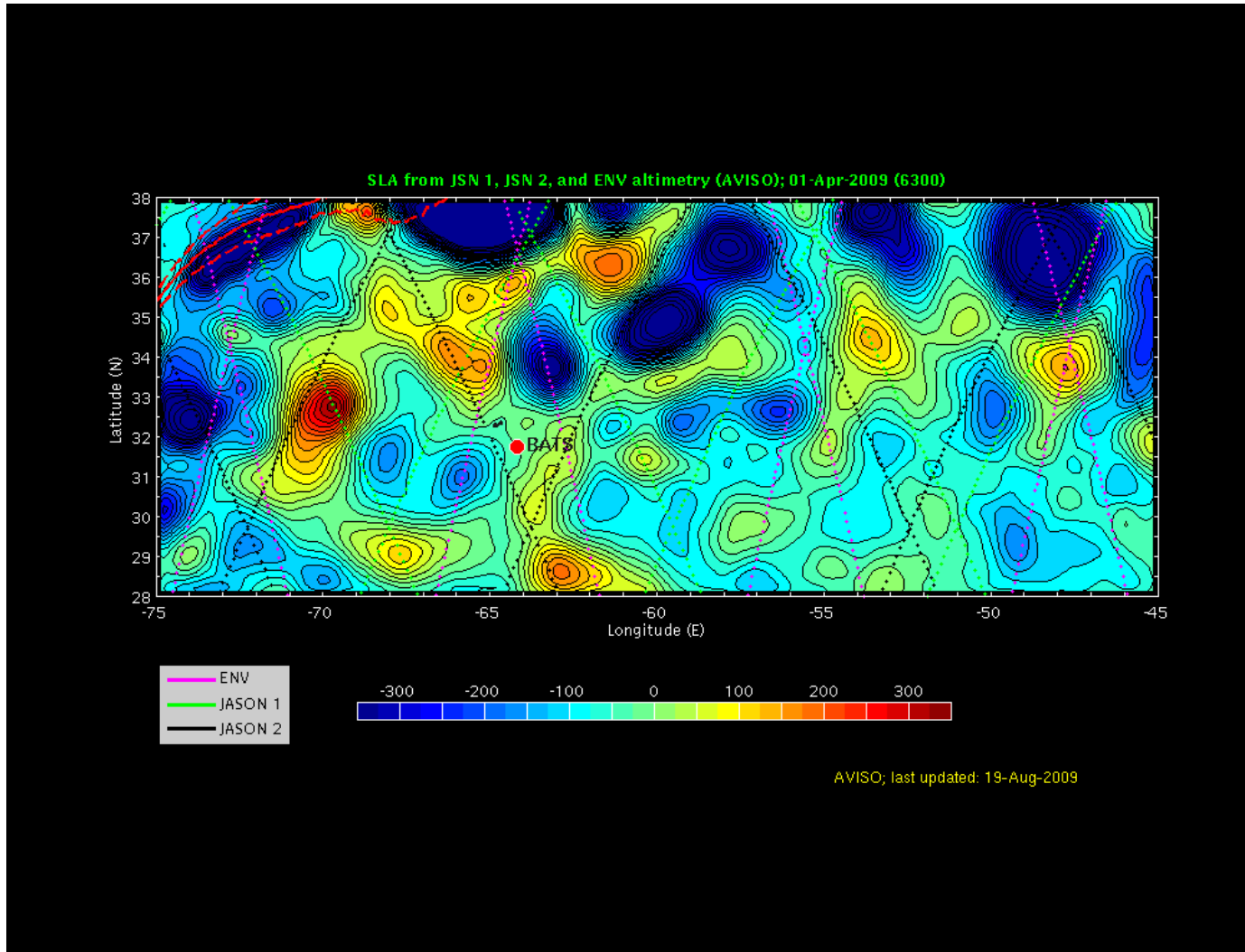
# Oceansites Network





# Ocean Variability

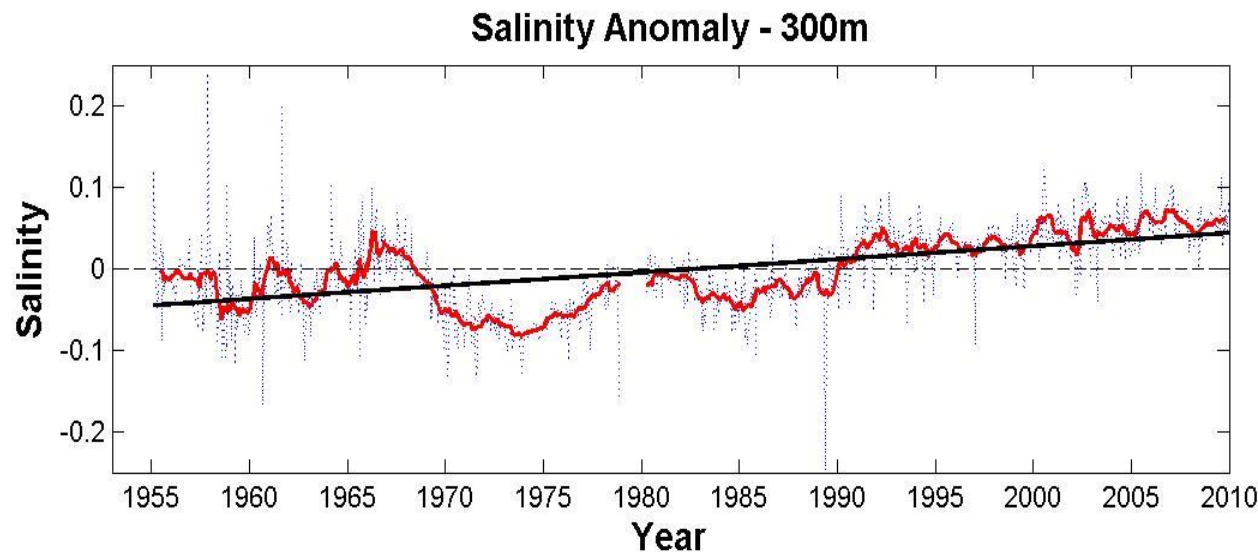
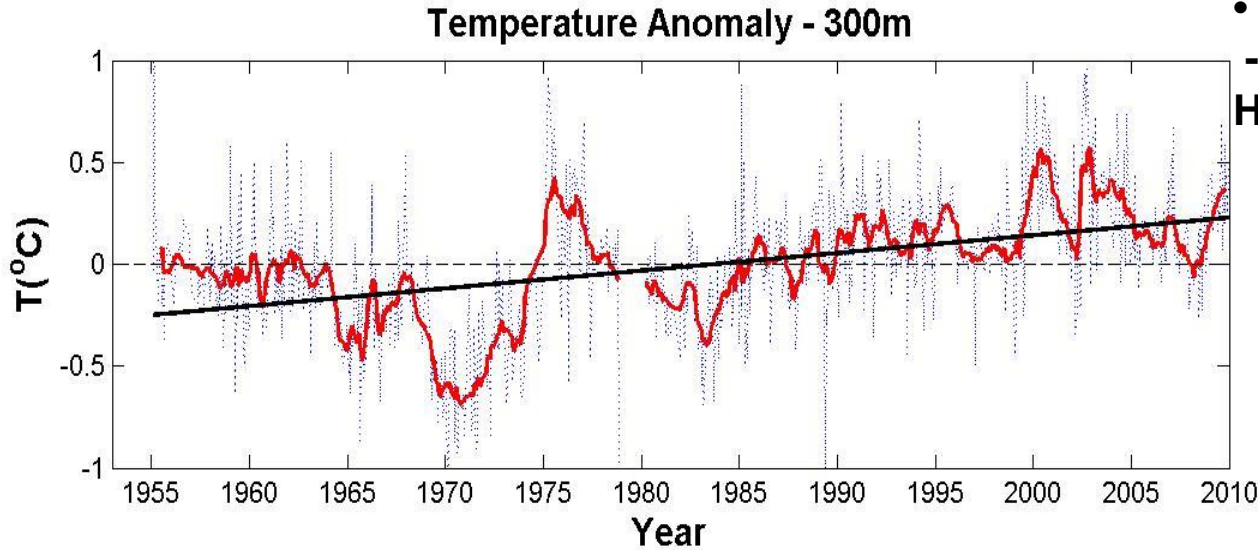
- Eddies in the Sargasso Sea influence year to year variability
- El Niño-Southern Oscillation and Arctic Oscillation influences



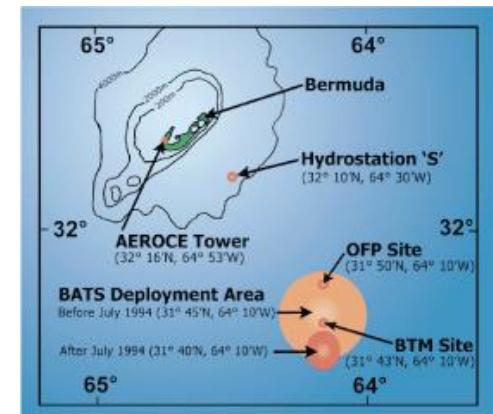
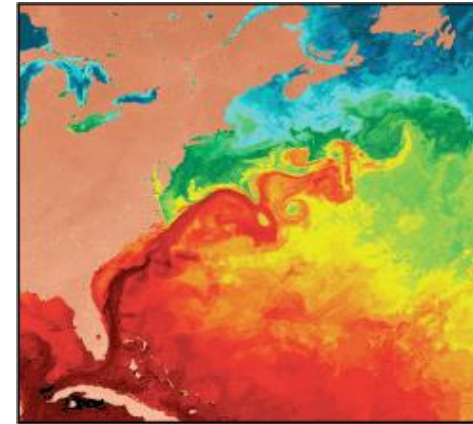


# Long term changes in the Atlantic

## Temperature and salinity changes in Sargasso Sea

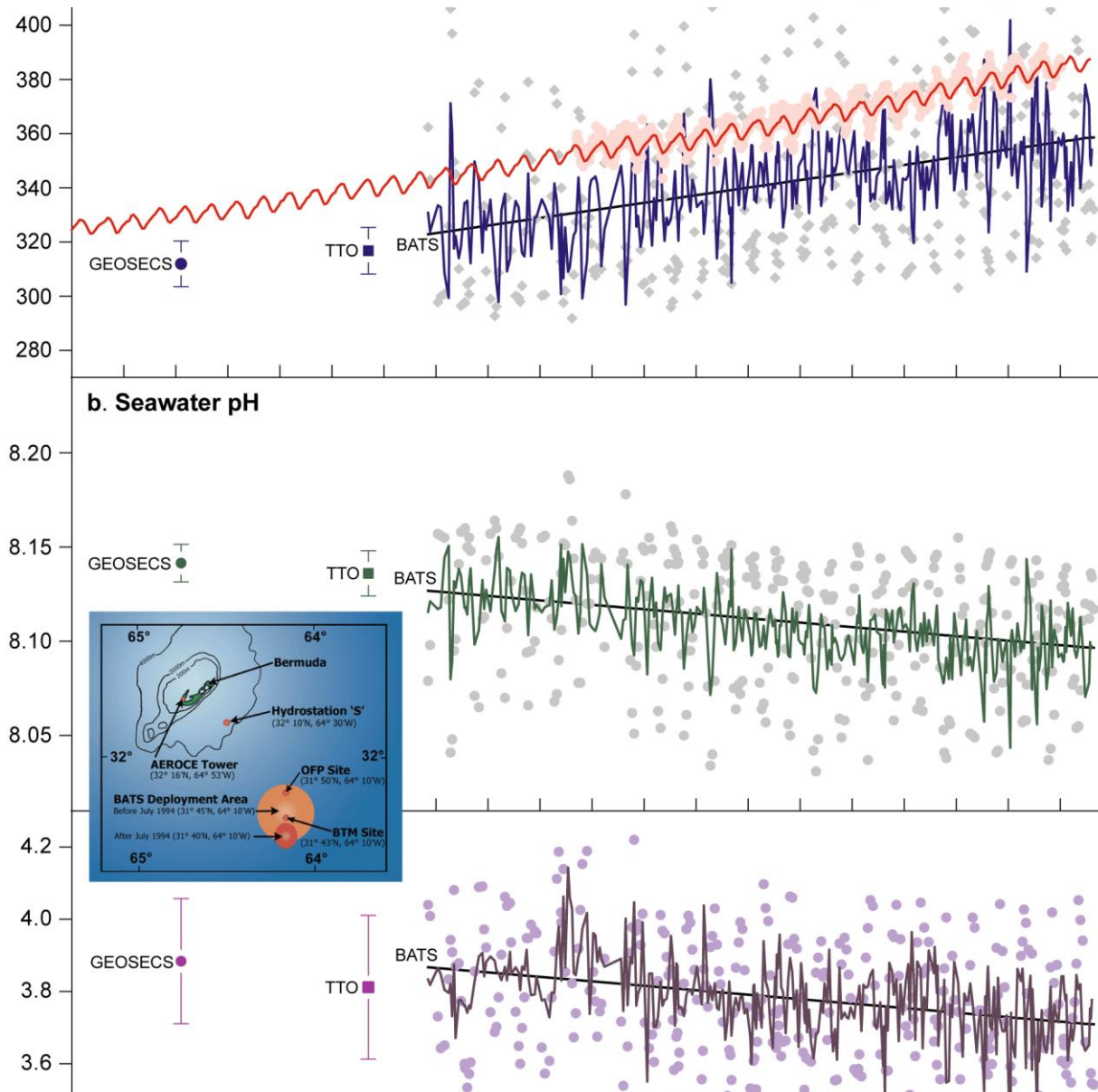


- Bermuda Atlantic Time-series Study (BATS; 1988-) Hydrostation S (1954-)

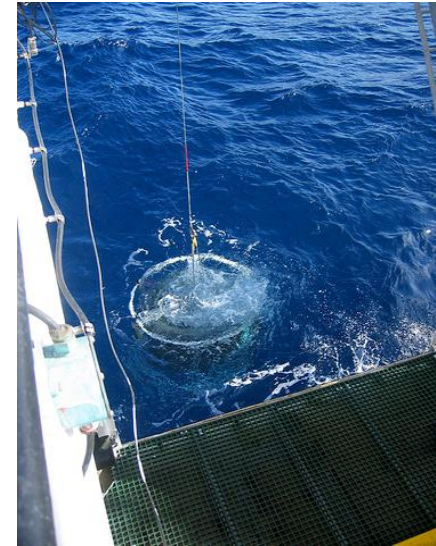


# CO<sub>2</sub> changes Ocean Acidification

## Decrease in ocean pH in the Sargasso Sea



Ship sampling



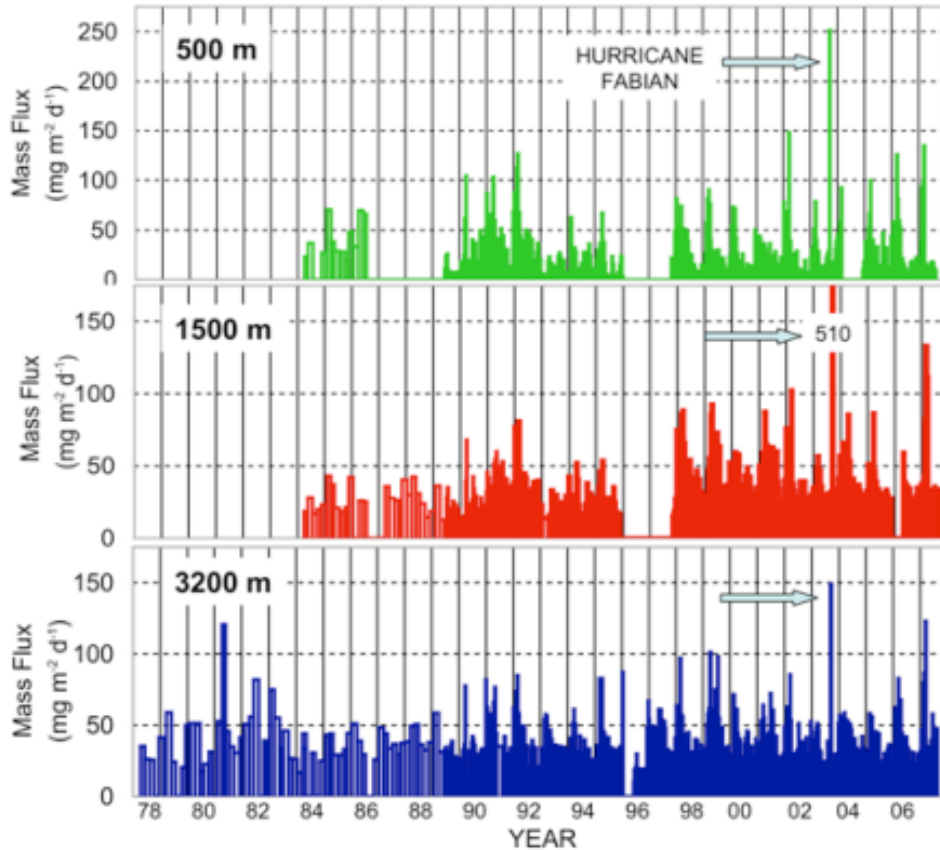
Analyses at BIOS



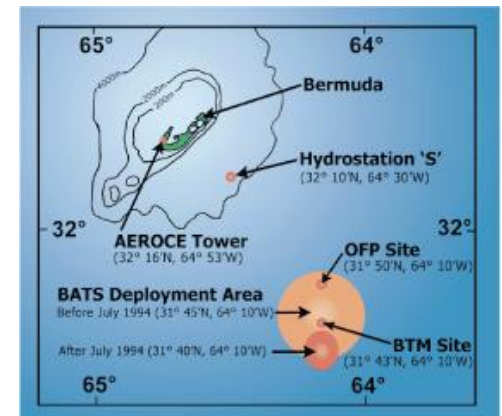
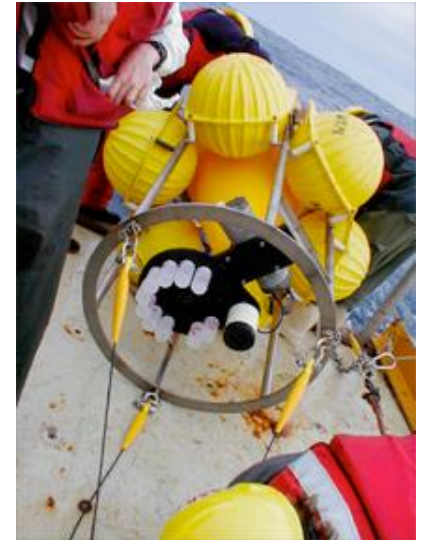
Nick Bates, BIOS, 2010

# Ocean Ecosystem Change

## Export of organic/inorganic matter to Sargasso Sea depths



## The Ocean Flux Program (OFP)



# Marine Ecosystem Changes at BATS

## Phytoplankton

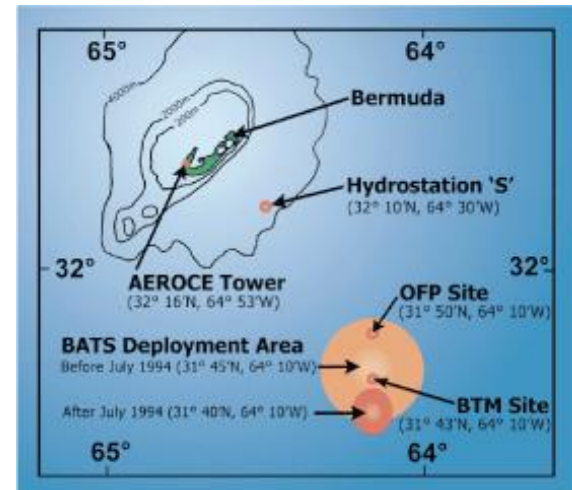
### Fewer Diatoms



### Fewer Coccolithophores

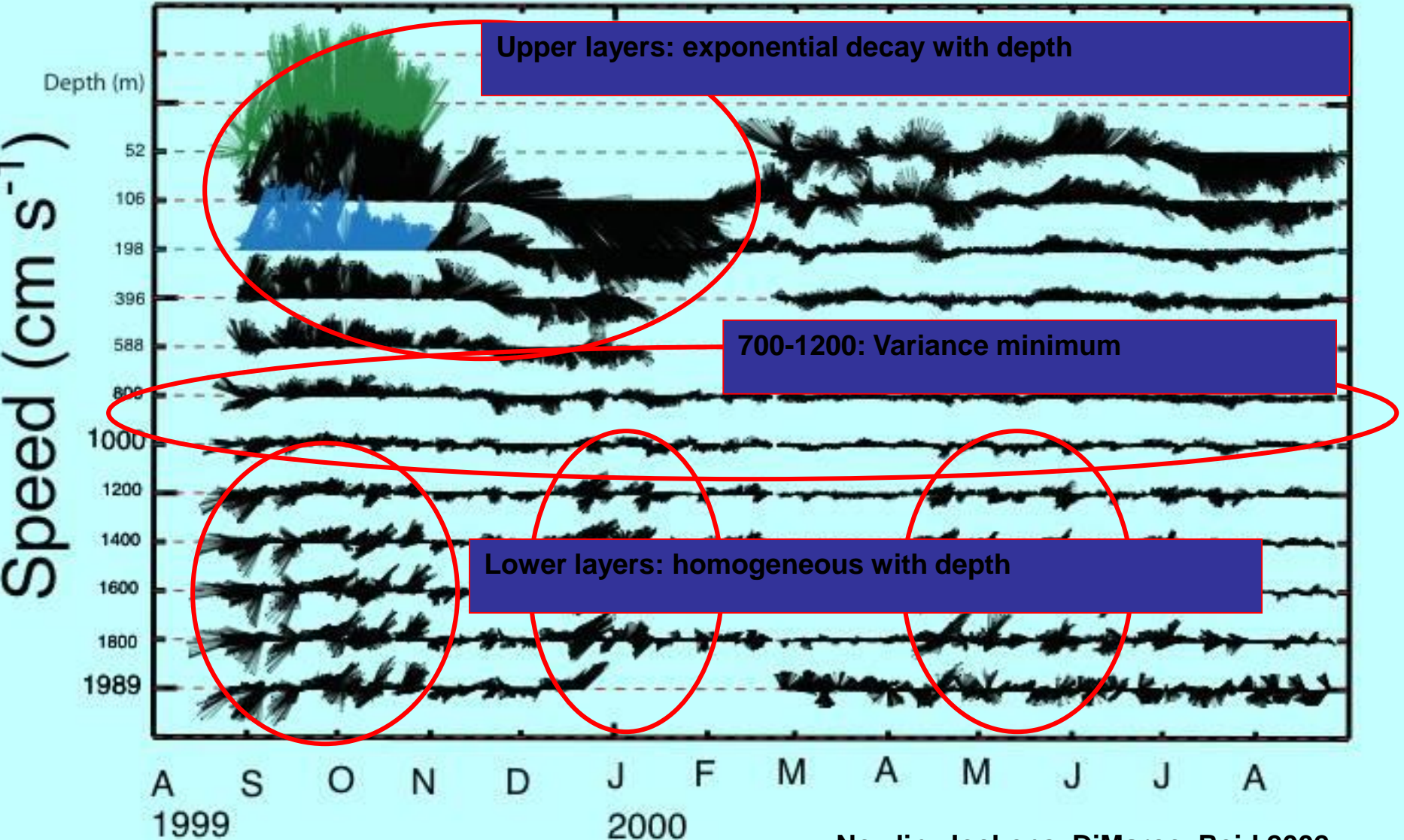


### More small phytoplankton (synechococcus)



Mike Lomas, Bigelow

# EIS Extension I1: NE of Green Knoll

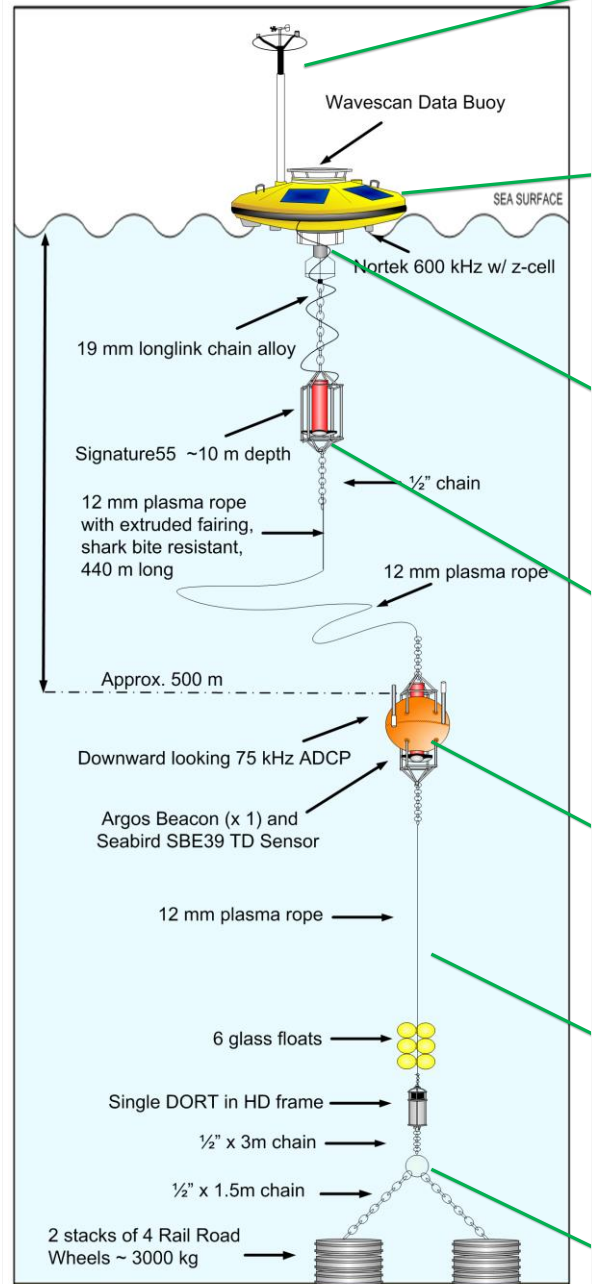


Nowlin, Jochens, DiMarco, Reid 2002

Note: Eddy Juggernaut

# Mooring Layout as deployed on 20 January 2015

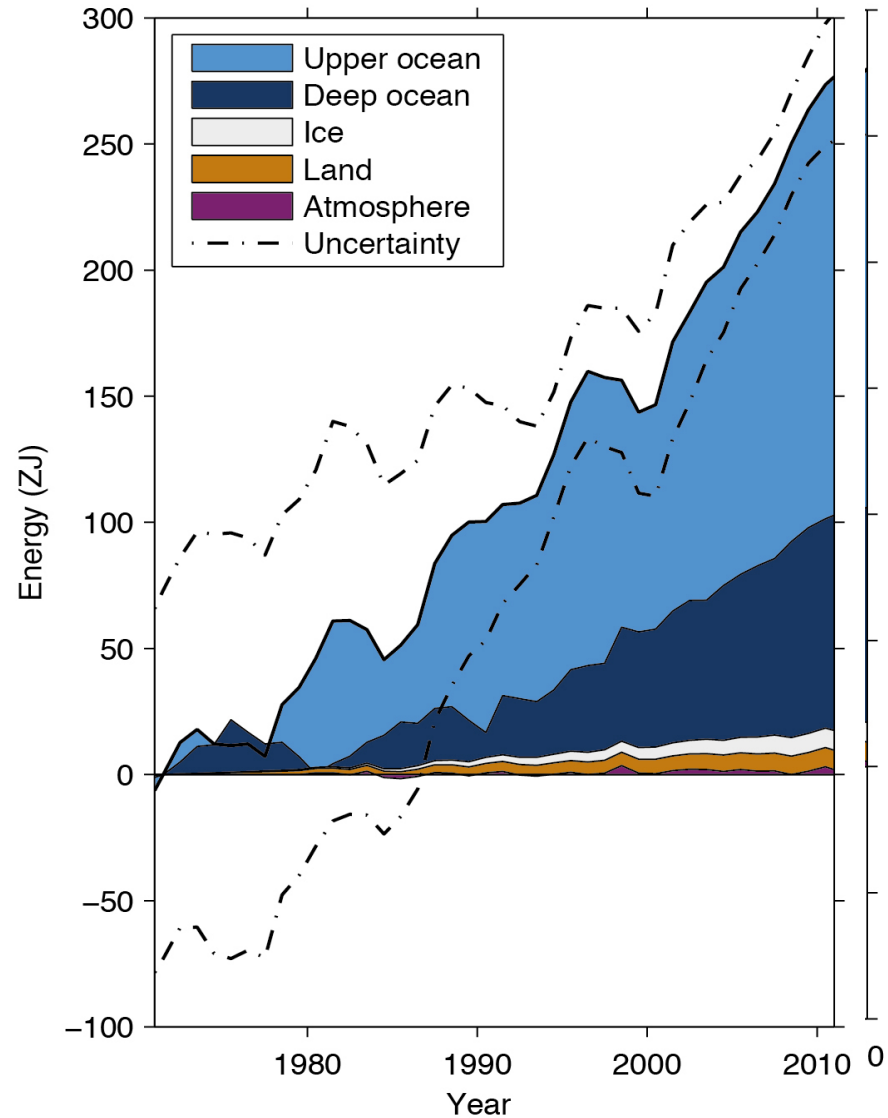
-- Shell's first long term, real time, deepwater metocean mooring in Gulf of Mexico

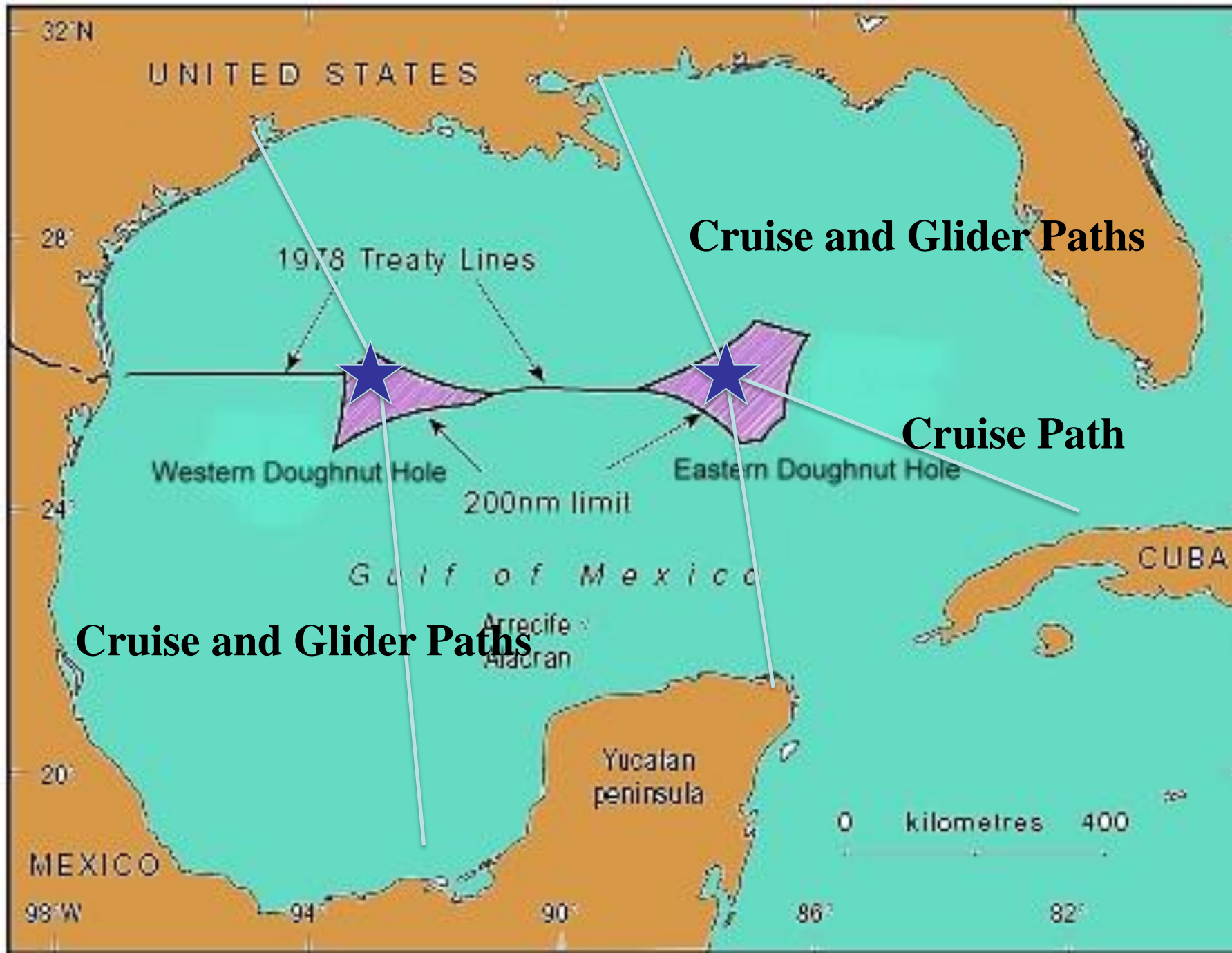


NOT TO SCALE  
Water Depth = 2,900 m

# Long-term measurements are Important ! IPCC

5<sup>th</sup> Assessment Chapter 3



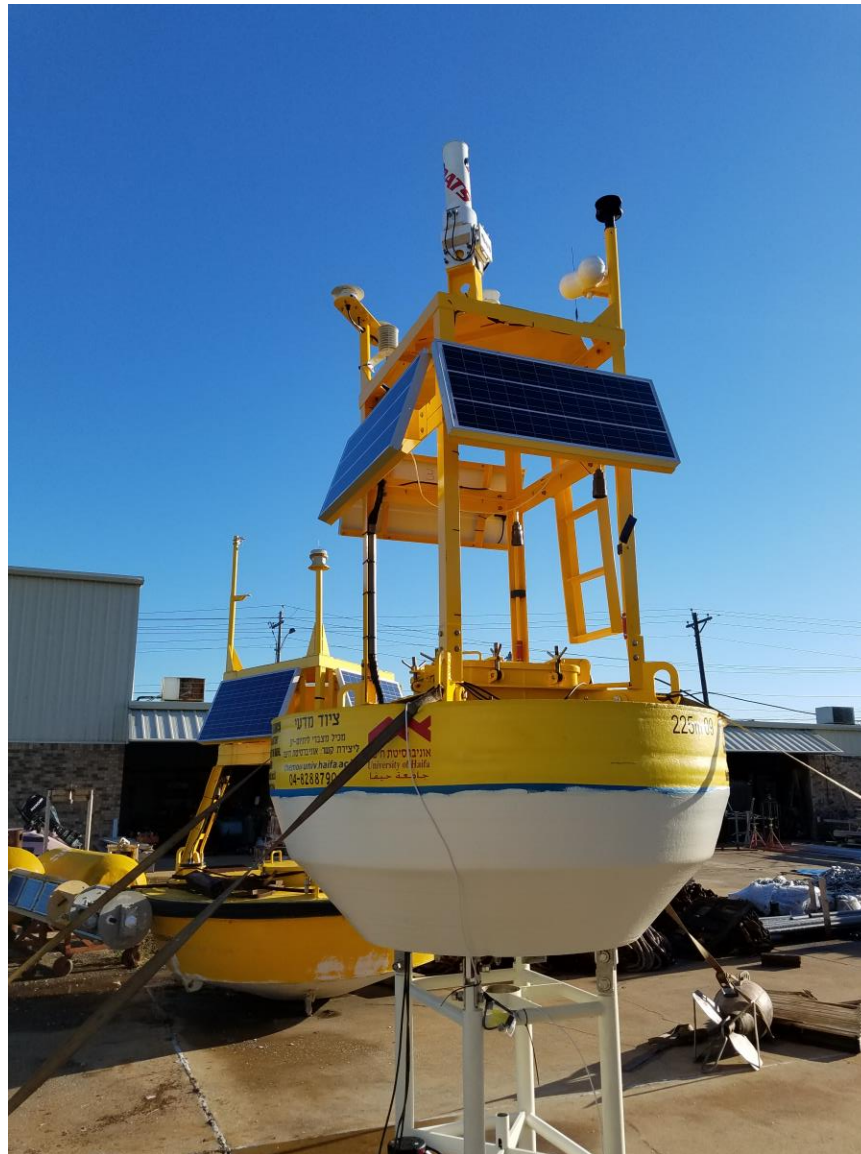


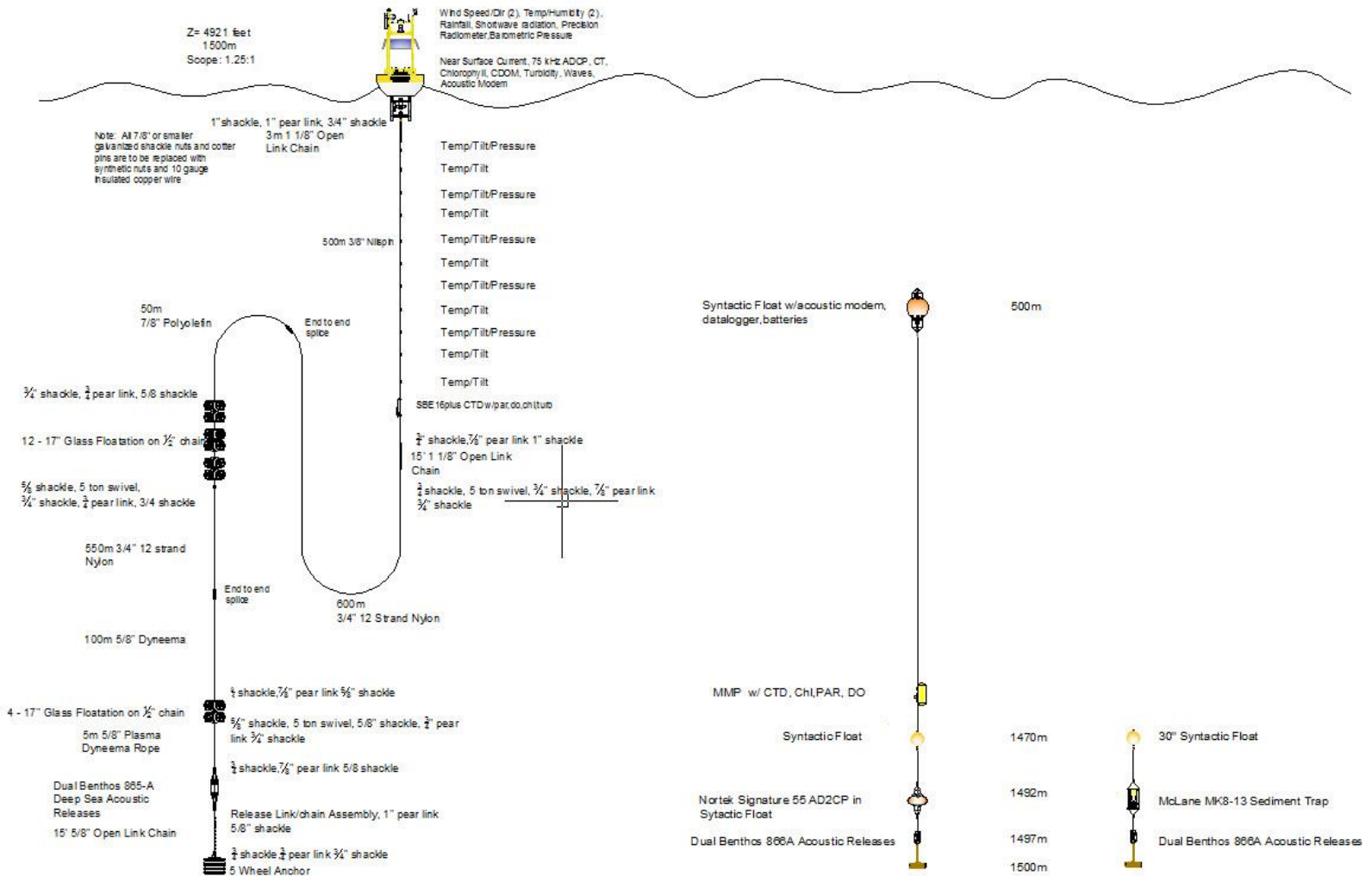
**Cruise and Glider Paths**

**Cruise Path**

**Cruise and Glider Paths**



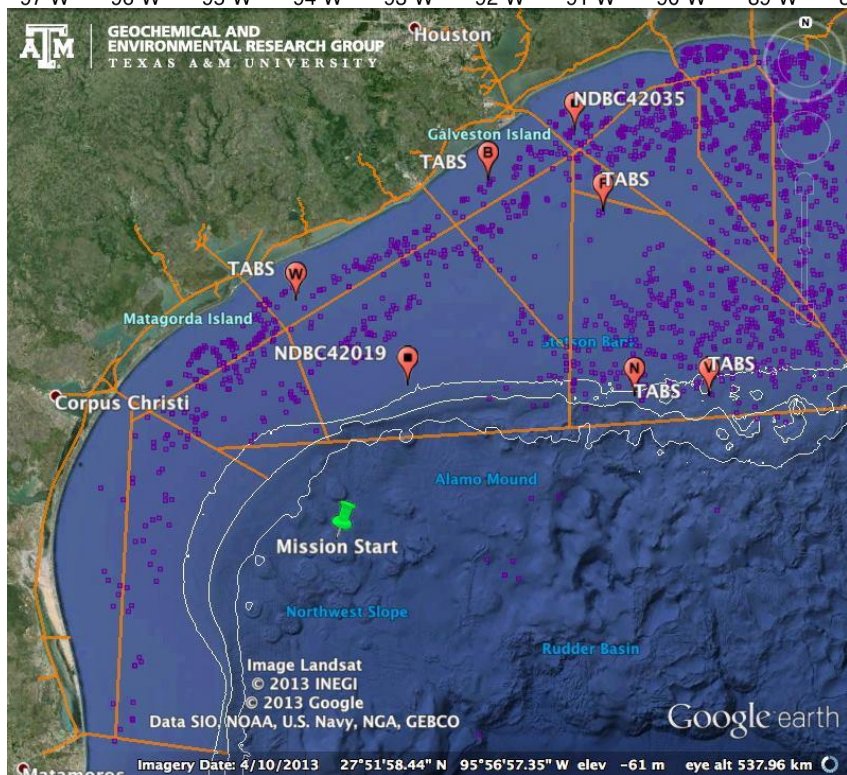
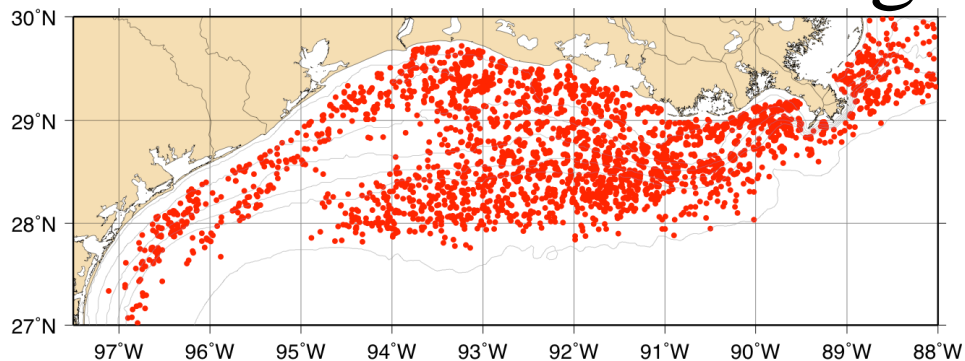




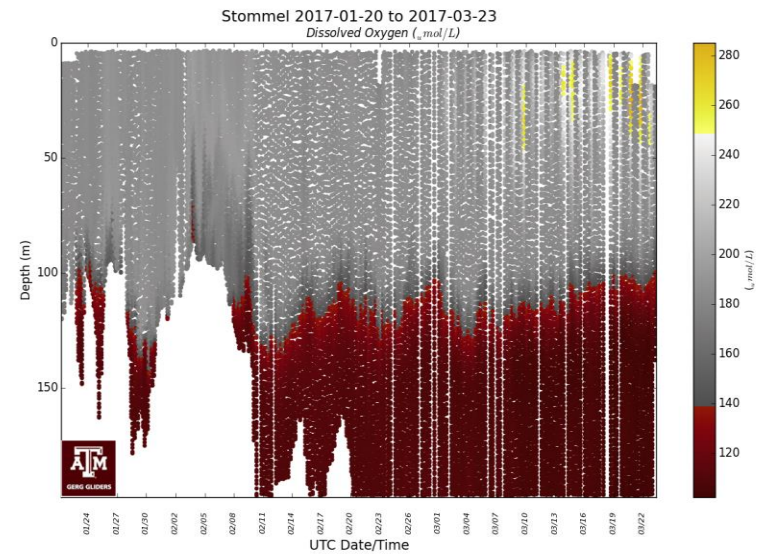
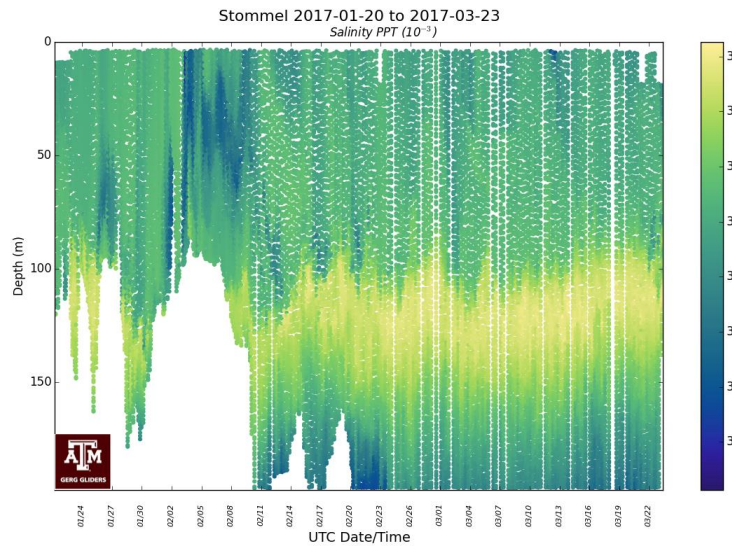
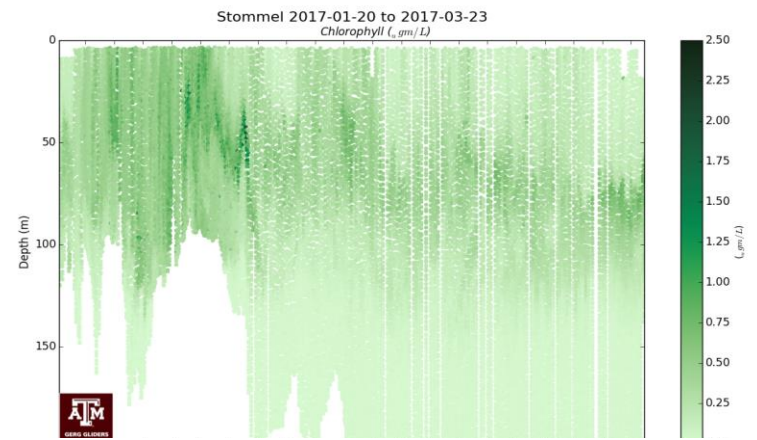
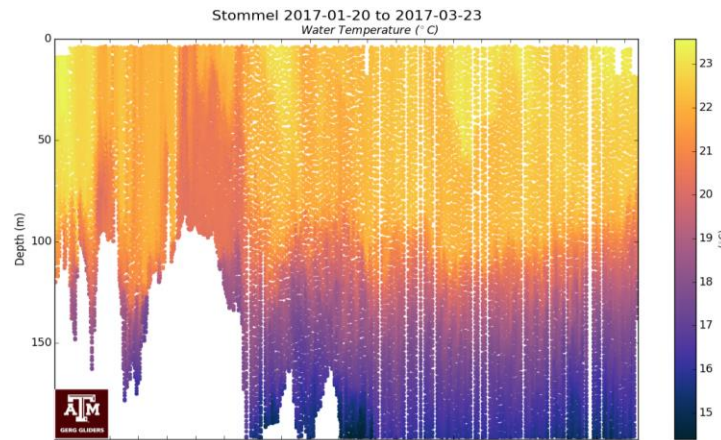
## Concerns of Open Ocean Long-Term Observations

- It is deep (pressure), remote (power)
- It is salty – (corrosive)
- It is rough much of the time – (resilience)
- Bio-fouling affects platforms and sensors (calibration, maintenance)
- Data transmission is limited (acoustics vs optics)
- Ship-time is expensive
- There is inherent variability of ocean parameters
- Requires a long-term funding commitment

# Glider Challenges in the GOM

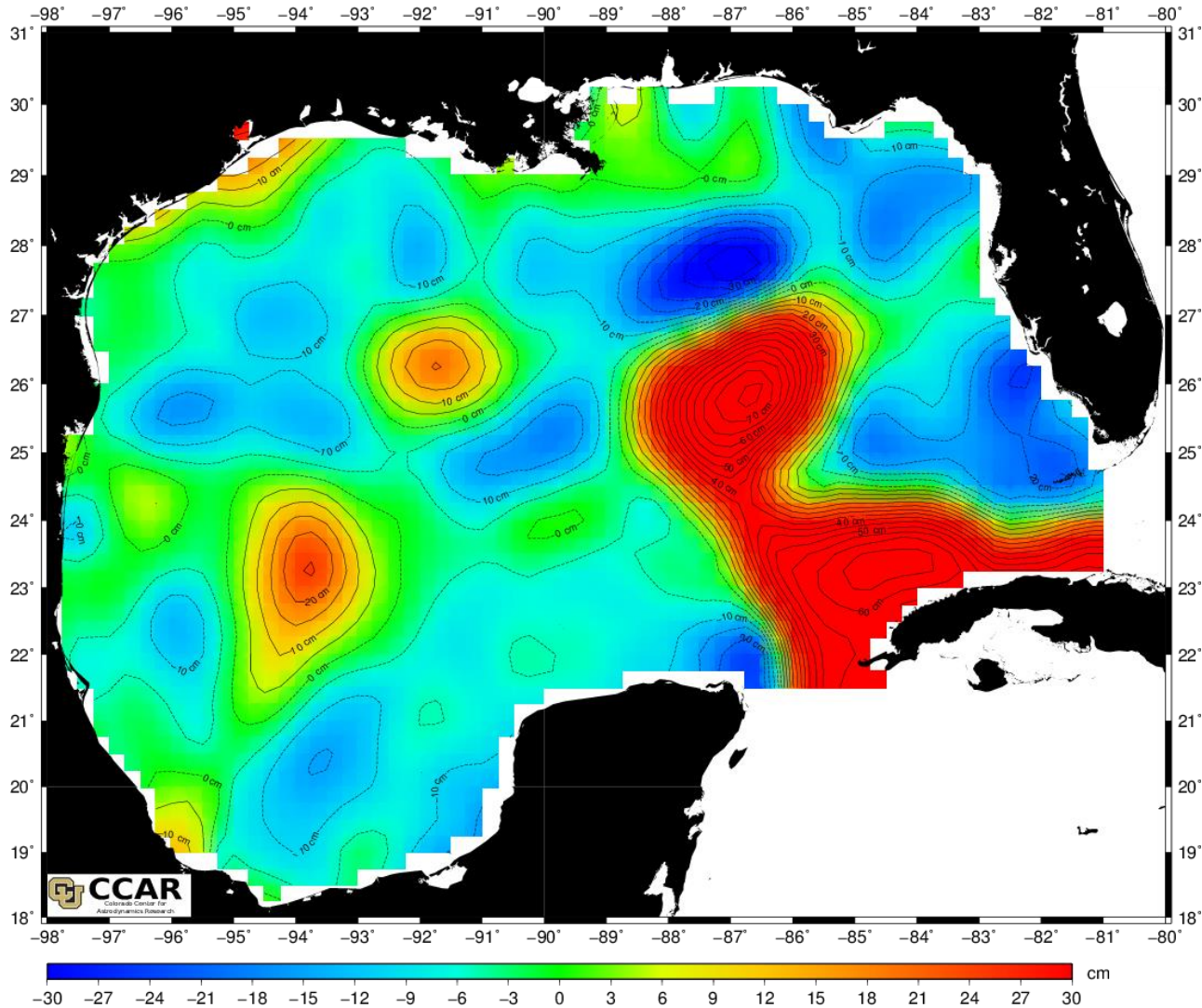


# Stommel March 23<sup>rd</sup> (68 days)

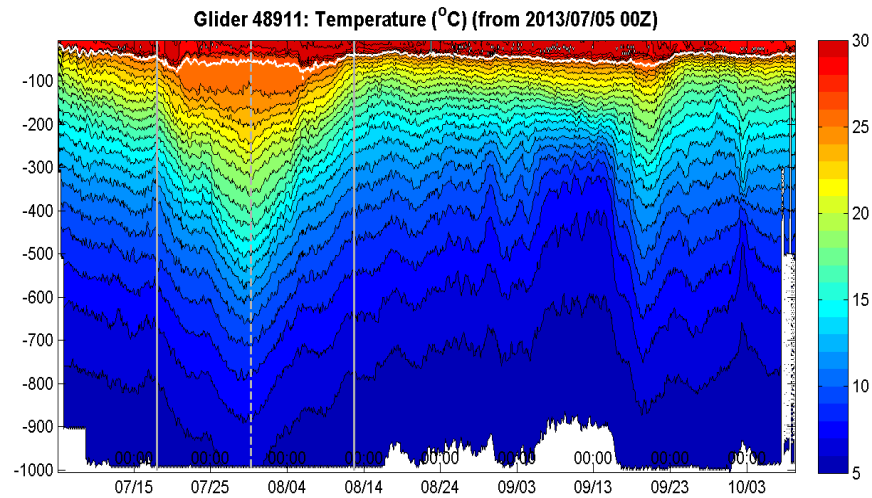
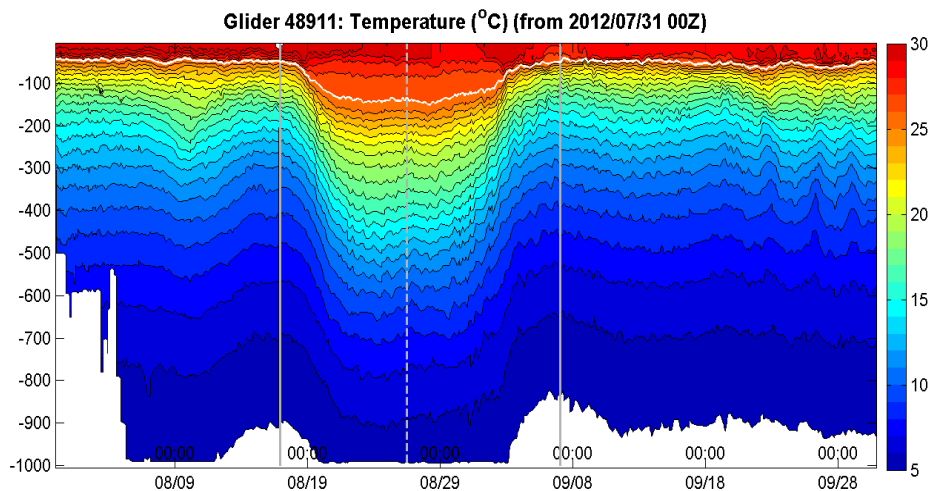
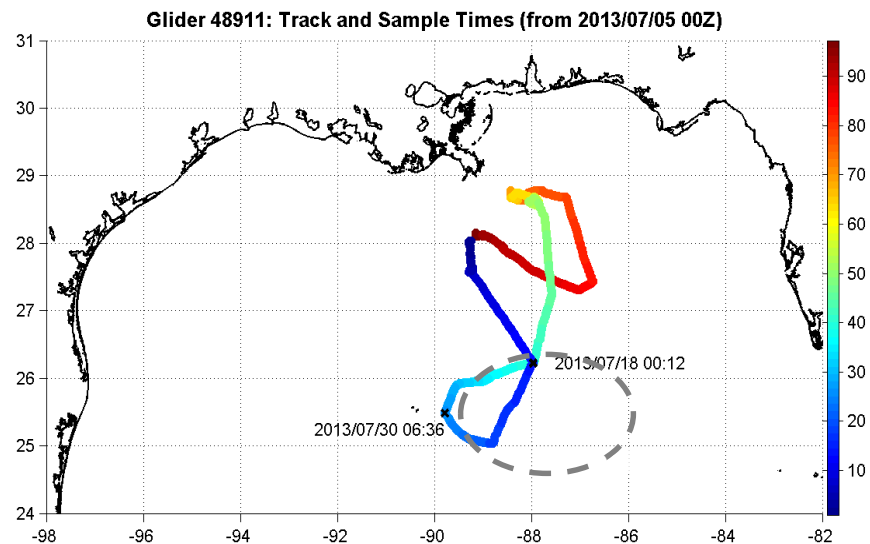
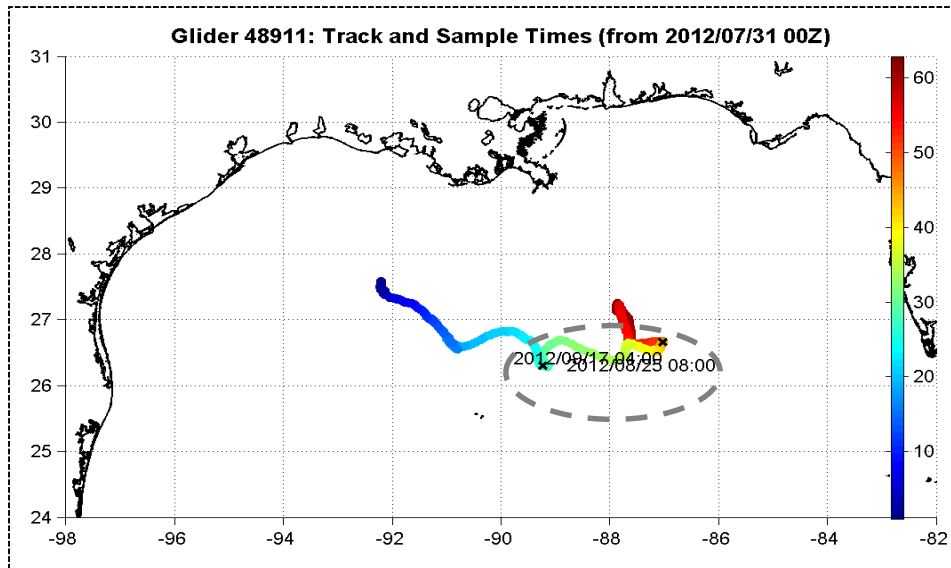


# Sea surface height Eddies

Realtime Mesoscale Altimetry – 04/04/2016



# NOAA Gliders GOM 2012 and 2013 temperature (courtesy NOAA)

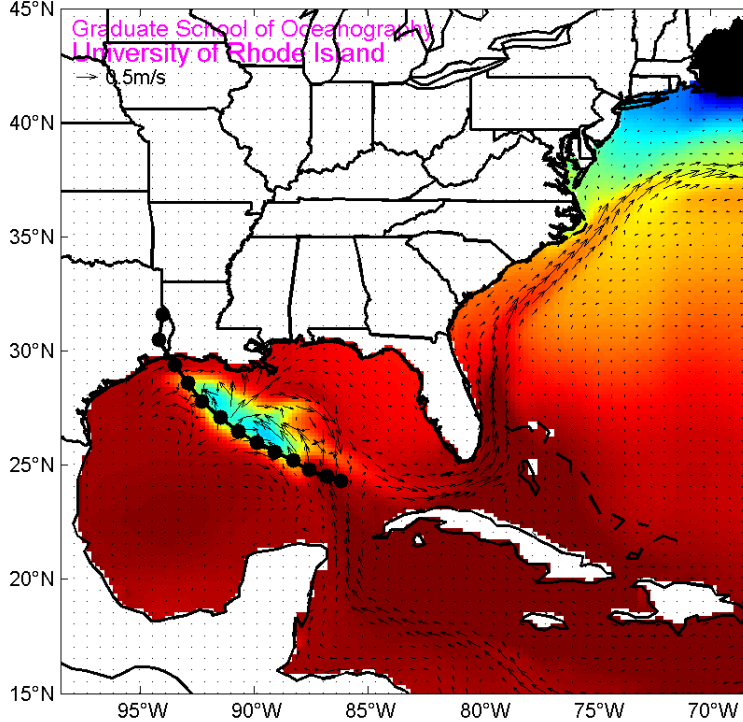


# Hurricane Rita

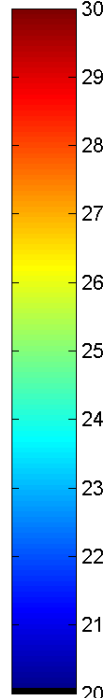
Sea Surface

75 m depth

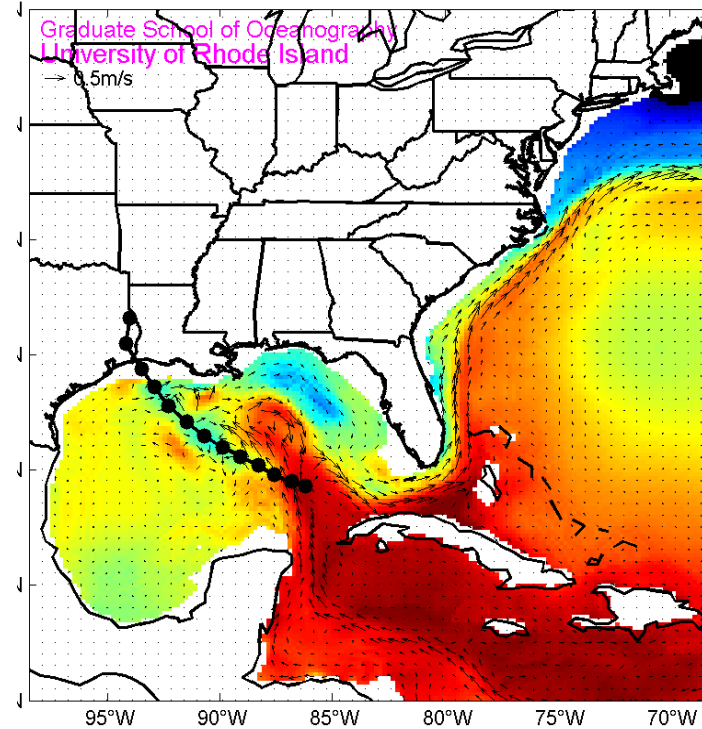
Hurricane RITA: Sea Surface Temperature and Current forecast for 09/24/05 18Z



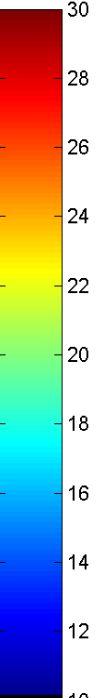
oC



Hurricane RITA: 75m depth Temperature and Current forecast for 09/24/05 18Z

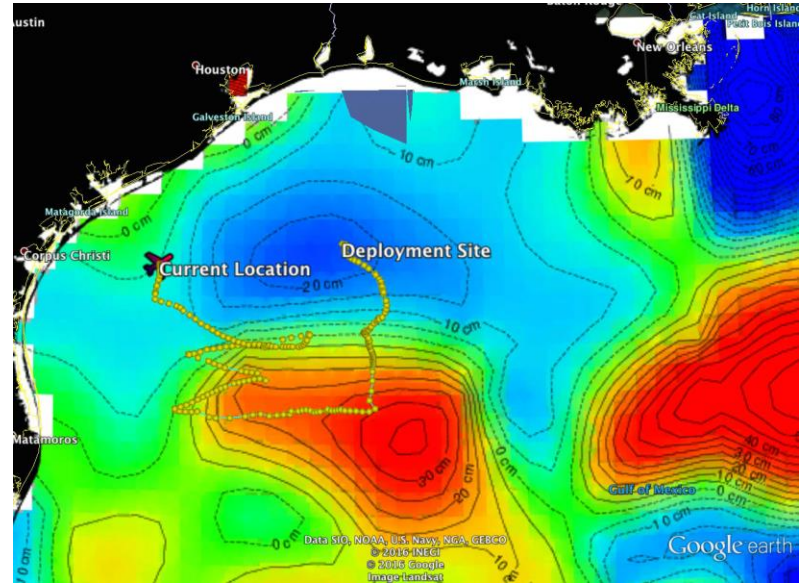
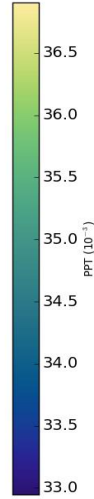
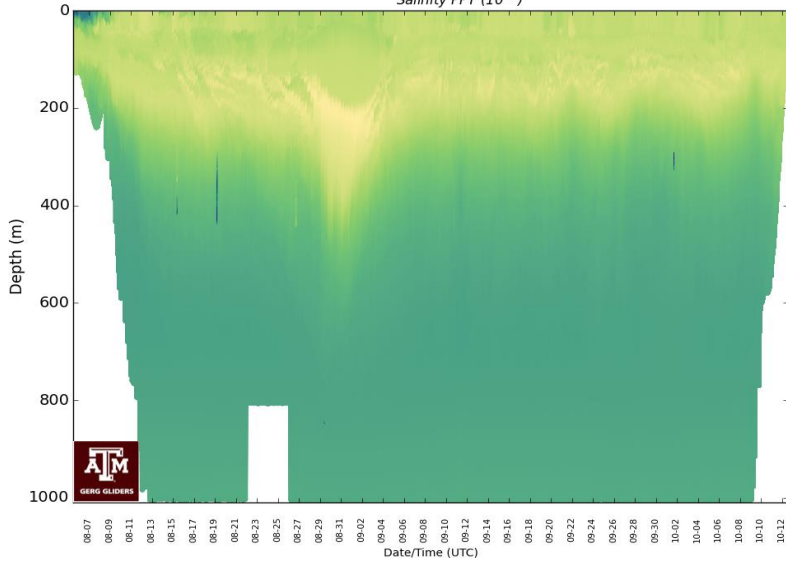


oC





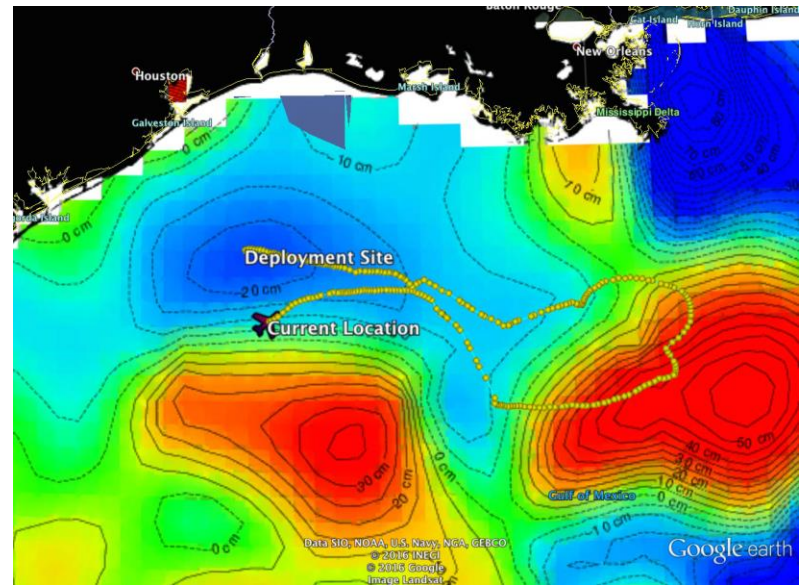
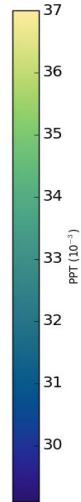
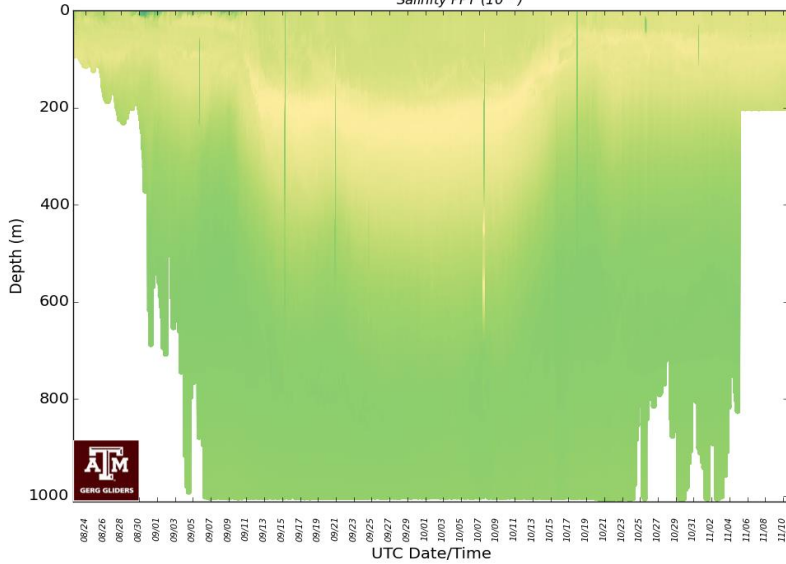
Stommel 2015-08-05 to 2015-10-12  
Salinity PPT ( $10^{-3}$ )



Google earth

miles  
km 200 400

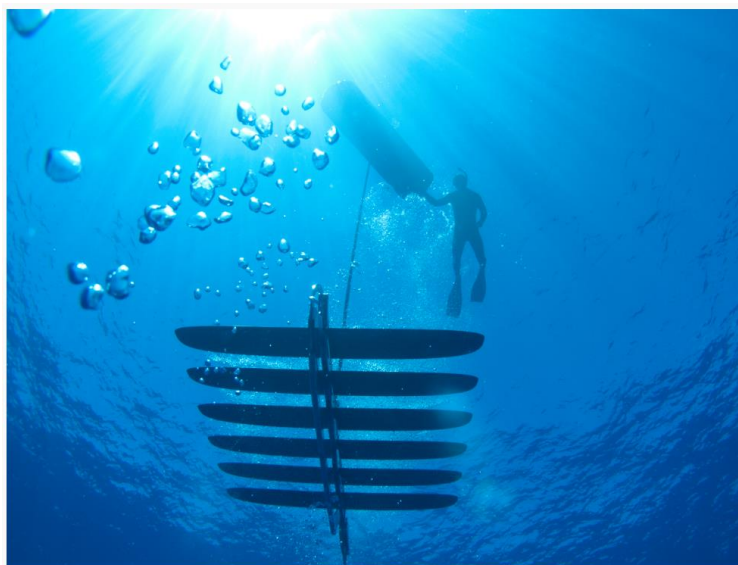
Sverdrup 2015-08-22 to 2015-11-10  
Salinity PPT ( $10^{-3}$ )



Google earth

miles  
km 200 400

# Liquid Robotics





# Estuary fish eDNAs in NYC estuary

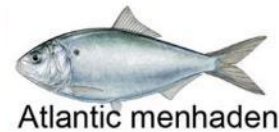
NYC/NJ Aquatic Vertebrate eDNA Project

Location: East River at 63rd ST, Manhattan

Date: October 30, 2015 Sample: 1 liter



## Fish eDNA



Atlantic menhaden



Herring spp



Black sea bass



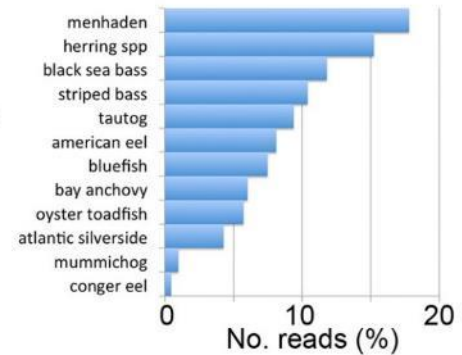
Striped bass



Tautog



American eel



Bluefish



Bay anchovy



Oyster toadfish



Atlantic silverside

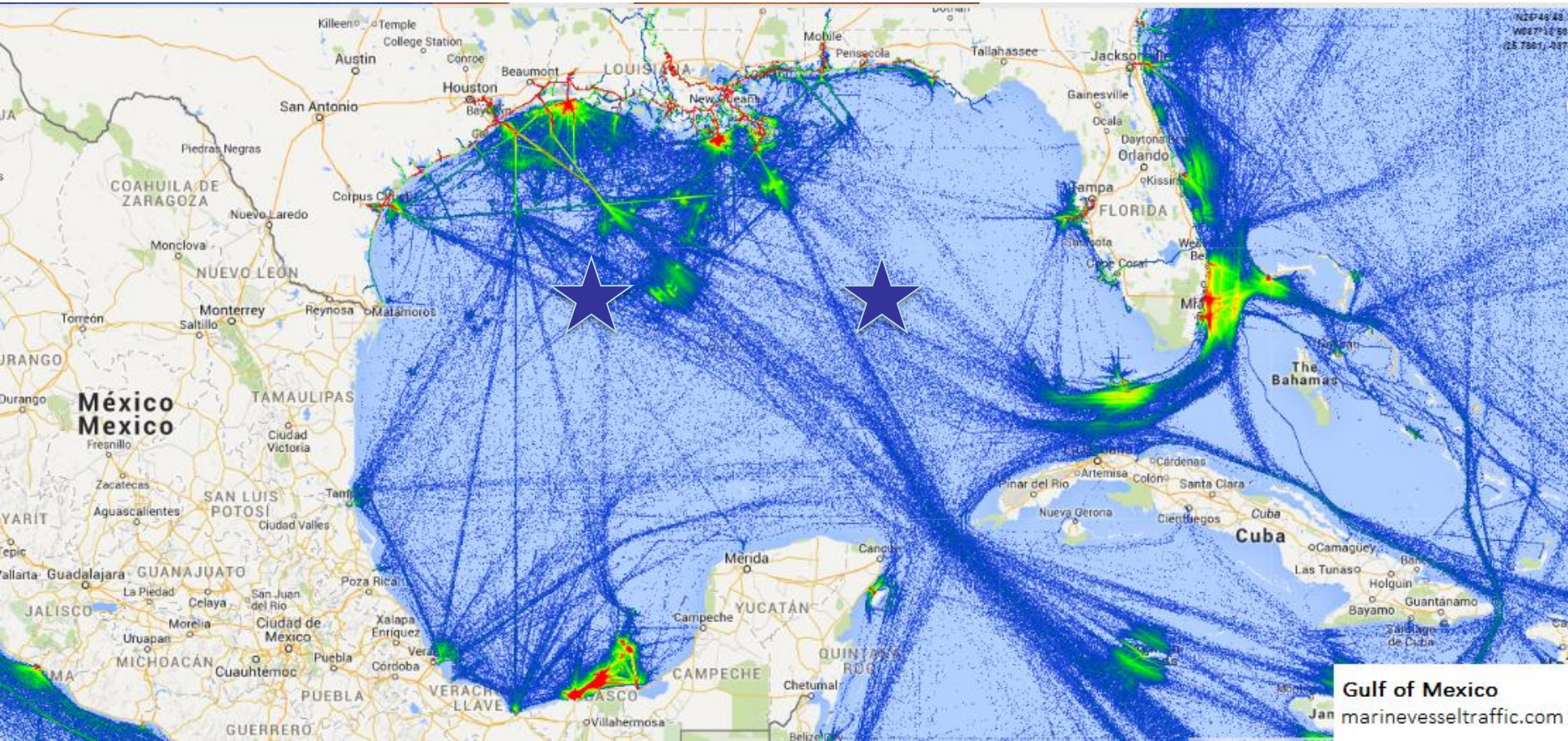


Mummichog



Conger eel

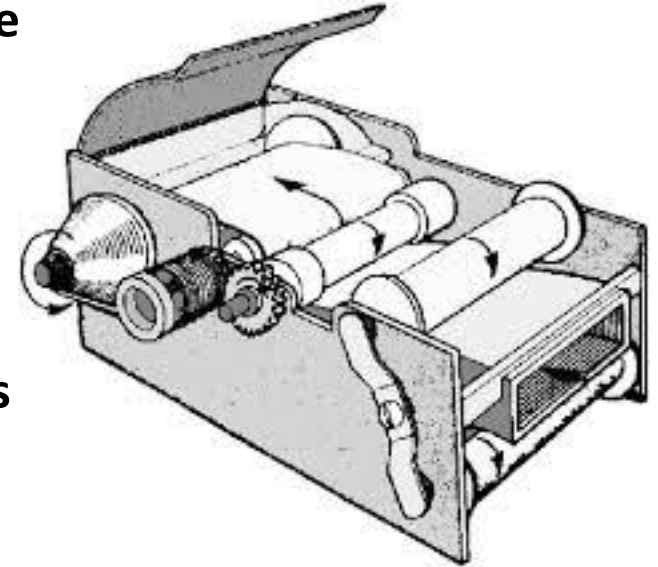
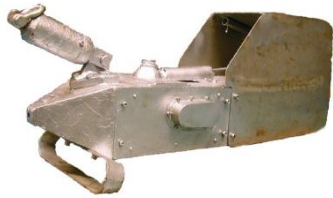
# “Ferry Box” Underway systems VoA cooling intakes



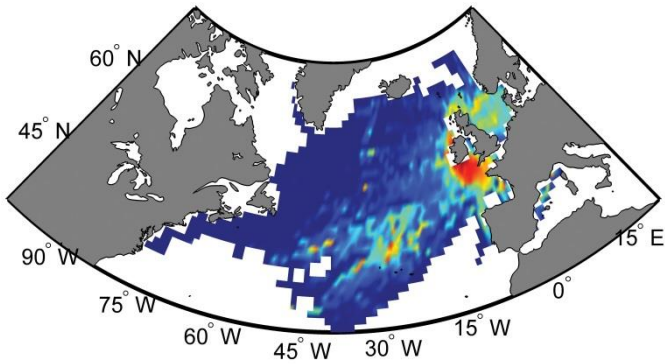
# Continuous Plankton Recorder (CPR)

Cost-effective Proven Reliable

- Designed by Alister Hardy in the 1920s.
- A robust device for collecting surface plankton over large spatial scales.
- Same methodology for 85 years comparable data.
- Capable of operating at high speeds (>20 knots).
- Designed to be towed behind ships of opportunity.
- 270  $\mu\text{m}$  silk filters (leno weave), but still captures the smallest microeukaryotes.



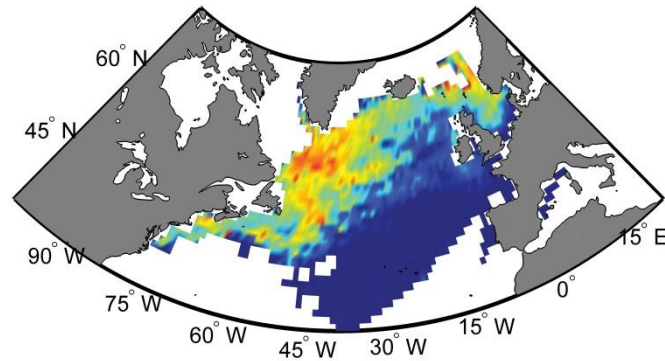
# First evidence of large scale northerly movement of zooplankton



## *Calanus helgolandicus*

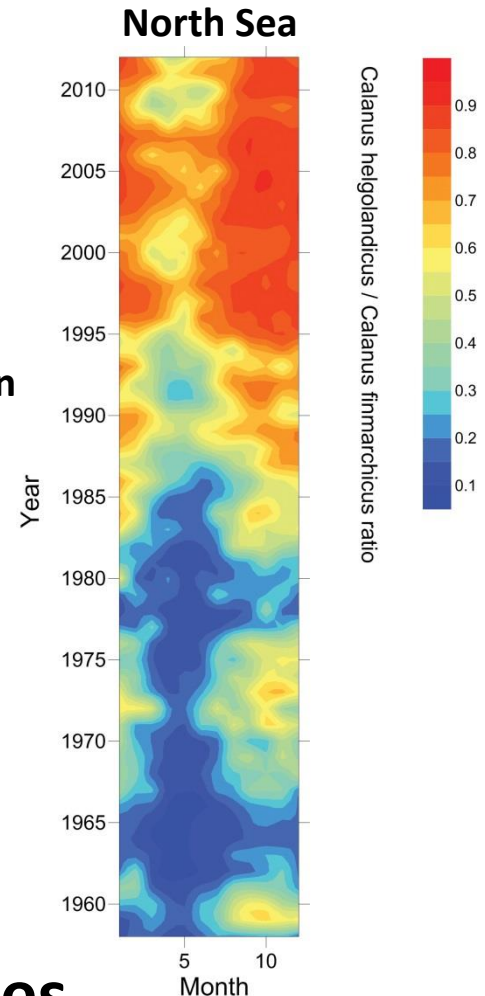
Warm water species  
Low lipid content  
Less nutritious

**1000 km shift in  
30 – 40 years!**



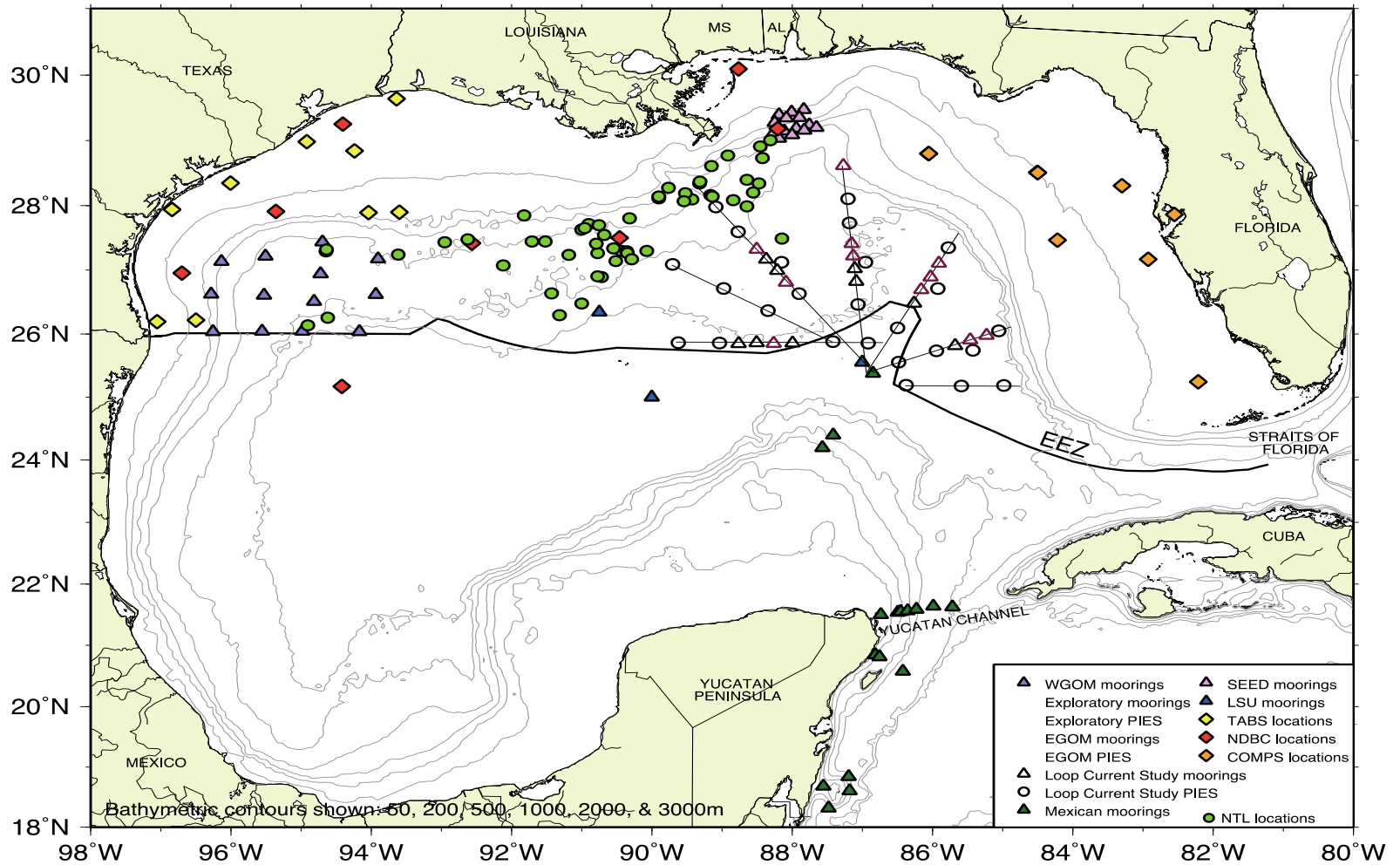
## *Calanus finmarchicus*

Cold water species  
High lipid content  
More nutritious



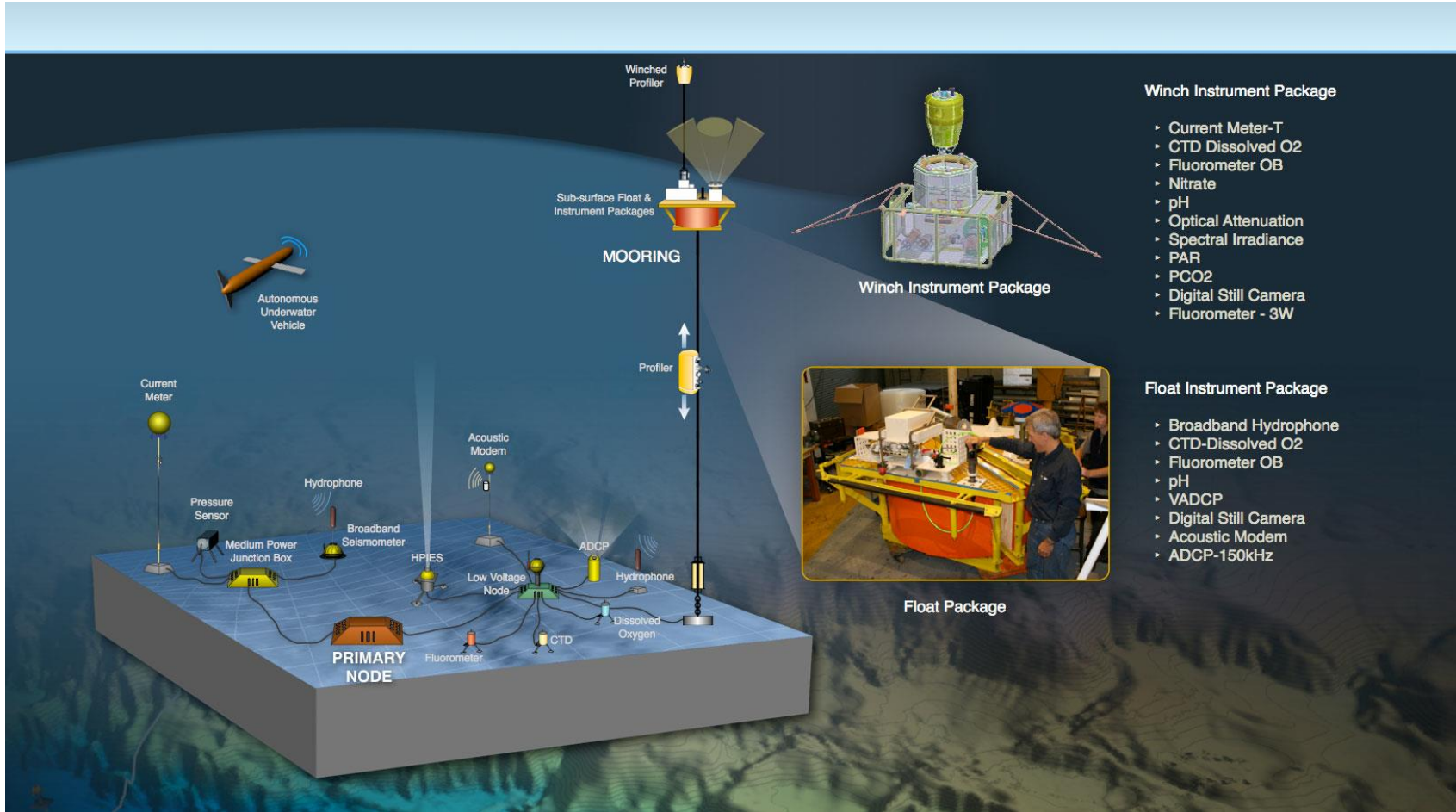
**Knock on effect for commercial fisheries.....**

# The Gulf of What ???





# Integrated Ocean Observing System for the GOM (Smart Gulf)



# Yucatan Channel velocities

CUPOM Mean (1993-1999) Current Vectors at the Surface

